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I. SUMMARY

In March and April 1993 investigators from the National Institute for Occupational Safety and Health (NIOSH) conducted a health hazard evaluation (HHE) regarding injuries occurring among employees who work in Superliner® sleeper cars for the National Railroad Passenger Corporation (Amtrak). NIOSH investigators specifically evaluated the operation of the Superliner® beds by reviewing records, interviewing employees, evaluating the dynamic forces involved with working the Superliner® beds, and observing work practices during the operation the trains.

The record review revealed that 22 injuries were reported in Superliner® bedrooms during the time period January 1, 1986, to April 30, 1993, making up 12% of all injuries among attendants in all Amtrak bedroom cars and 1.2% of all injuries among employees on Amtrak trains. Body areas most frequently injured included the back, arm, head, and eyes. Twenty-one of 22 injuries were of the 'sprain' or 'bruise' type. Reasons for the injuries (being struck by a falling bed, injury while attempting to move a bed, or falling from an elevation) were analyzed using the fault tree analysis technique.

An evaluation of injuries occurring among employees of the National Railroad Passenger Corporation (Amtrak) who work in Superliner® sleeper car bedrooms revealed that injuries among these train attendants make up 12% of injuries among attendants working in all Amtrak bedroom cars. Inadequate maintenance and inadequate training were identified as factors involved in many of the injuries. Recommendations were made to management and employees concerning train maintenance, training and supervision of employees, and engineering controls.

KEYWORDS: SIC 4011 (Railroads, Line Haul Operating); Ergonomics, Musculoskeletal Injuries, Train Attendants, Superliner® beds.

II. INTRODUCTION

On January 13, 1993, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from the Transportation Communication International Union (TCU) regarding injuries occurring among employees who work in Superliner® sleeper car deluxe and economy bedrooms for the National Railroad Passenger Corporation (Amtrak). In the HHE request, NIOSH was asked specifically to evaluate the mechanisms for raising and lowering the upper Superliner® beds, as well as the mechanisms for holding these beds in the upright position.

On March 10, 1993, NIOSH investigators conducted an initial site visit to the Amtrak repair facility in Beech Grove, Indiana. At this site visit, the original design of the Superliner® beds and subsequent engineering changes were reviewed. In addition, a walk-through was conducted of a sleeper car which was being overhauled. On March 23-24, 1993, a second site visit was conducted at Amtrak's Midwest Division headquarters in Chicago, Illinois. During this site visit, NIOSH investigators, accompanied by TCU and Amtrak representatives, rode round-trip on an Amtrak Superliner® train between Chicago and Kansas City to observe employee work practices and evaluate the dynamic forces involved in working in the bedrooms of a moving train. In addition, a brief tour was conducted through Superliner® trains just beginning or completing servicing at the Chicago 14th Street Yards. Preliminary conclusions and recommendations were made to management and employee representatives in a letter dated October 21, 1993.

III. BACKGROUND

Superliner® sleeper cars were put into service in approximately 1978; the older line of Amtrak equipment which included sleeper cars is called Heritage equipment. As of March 1993, there were 68 Superliner® sleeper cars in service. Each sleeper car has five deluxe bedrooms, each of which contains equipment for one upper bed and one lower bed. There are 14 economy rooms per sleeper car, with each containing equipment for upper and lower beds, although of a different configuration than those found in the deluxe rooms. Each sleeper car also contains one family room and one handicap room which have a total of six beds (three upper and three lower). Therefore, there are 22 upper beds and 22 lower beds per sleeper car.

The original design of the Superliner® deluxe upper beds included a fiberglass bed frame mounted to the wall with a spring mechanism extending into the body of the bed frame. The bed was held in the down position by two mechanisms: (1) positive latch on the inboard side; (2) scissor arm on the outboard side. The bed was held in the up position by two nylon straps equipped with hooks which fit into receptacles in the ceiling. Several modifications of the original upper bed design have occurred:

a) A steel cable counterweight mechanism was added to some beds; as of March 1993, there were approximately 14 sleeping cars with this type of mechanism.

b) As sleeping cars are being overhauled, a bungee cord mechanism is being added to all upper beds, replacing any previous modifications. This mechanism is designed to decrease the amount of force required of the attendant when operating the bed. As of March 1993, there were approximately 54 sleeping cars with this type of mechanism.

c) As sleeping cars are being overhauled, all fiberglass beds are being replaced with stainless steel beds. As of March 1993, there were approximately 54 sleeping cars with this type of bed.

d) A new positive latch mechanism is being installed on all upper beds designed to keep the bed in the up position (in addition to the nylon straps). This mechanism has been installed in one sleeper car as of March 1993.

The design of the economy beds currently being used has not been changed from the original design.

The upper beds include a fiberglass frame mounted to the wall with a spring mechanism extending into the body of the bed frame. The bed is held in the down position by a positive latch mechanism which is operated from a central handle on the bed frame. The bed is held in the up position by the same latch mechanism within the bed frame. The latch mechanism works in combination with plastic 'stops' which are mounted on the wall. There is also an intermediate 'stop' which is designed to slow the bed when the bed is being taken down.

The employees primarily responsible for working in the bedrooms and with the beds are the sleeping car attendants (SCA). The supervisors of the SCAs, the on-board services chiefs (OSC), may also operate equipment in the bedrooms occasionally. The duties of the SCAs include providing general train services to sleeping car passengers and performing housekeeping in the bedrooms.

IV. EVALUATION METHODS

During the site visits, NIOSH representatives conducted informal interviews with the SCAs and OSCs regarding musculoskeletal hazards associated with their jobs, observed work practices, evaluated the dynamic forces involved in working in the bedrooms of a moving train, videotaped the upper bunk operating process, and measured and recorded workplace dimensions. Using these data, a system safety analysis and a computer simulation of bedroom safety were performed. The system safety analysis involved: (1) analysis of the bunk system using the fault tree analysis technique to determine the primary causes of hazards (primary fault events) and the likelihood that a hazard will cause an unwanted event; and (2) development and implementation of controls to reduce or eliminate hazards in order to maintain an acceptable level of safety. The computer simulation of attendants' functional reach was performed to evaluate the overexertion risk of employees in operating existing upper bunks.

Amtrak records relating to injuries in Superliner® bedrooms were reviewed. The injuries recorded by Amtrak are Federal Railroad Administration (FRA)-reportable injuries. FRA-reportable injuries include injuries to a railroad employee that:
(1) occur in the work environment; and (2) require medical attention or result in:
a) restriction of work or motion for one or more work days; b) loss of one or more work days; c) termination of employment; d) transfer to another job; or
e) loss of consciousness.

In addition, the Employee Instruction Manual for new employees, dated
June 15, 1988, and the written instructions for bunk operation posted on the wall of each room were reviewed.

V. RESULTS AND DISCUSSION

Record Review

Injury data are presented in Tables 1 and 2. There were 22 injuries reported in Superliner® bedrooms in the time period January 1, 1986, to April 30, 1993. These injuries comprise 12% of the 182 injuries reported in bedrooms from Superliner® and Heritage equipment combined. There were 1892 injuries among all employees on Amtrak trains during that time period. The 22 injuries in Superliner® bedrooms make up 1.2% of the total 1892. As shown in Table 1, Superliner® sleeper cars make up approximately 37% of all Amtrak sleeper cars (Superliner® and Heritage equipment combined), and account for 51% of the travel capacity in terms of potential number of passengers in bedrooms.

Table 2 presents data which characterize the reported injuries. Of the
17 Superliner® sleeper cars involved in the 22 injuries, five cars had two reported injuries each. The other 12 cars had one reported injury each. The back, arm, head, and eyes were the body areas most frequently involved in the injuries, and all but one injury involved a sprain or bruise. The most common reasons given for the injuries were being struck by a falling bed, injury while

attempting to move a bed, or falling from an elevation. Twenty of 22 injuries involved train attendants; the other two involved employees with other job titles performing job duties similar to those of the train attendants. No employee was reported as being injured more than once. The mean number of lost days for all injuries was 22 (range 0-105). Those with back injuries averaged 43 lost work days per injury (range 0-105). The mean age of injured train attendants was 39 (range 23-67) while the mean age of all Amtrak train/service attendants was 41.

The Amtrak Employee Instruction Manual (Chapter 8, Section F, Part 3, Train Attendant - Sleepers, pp. A-8-45 - A-8-60) has detailed instructions for many of the duties of sleeping car attendants, including proper procedures for bed-making. However, there are no instructions concerning the mechanics of operating the upper and lower beds of Superliner® bedroom cars. Employees reported that new attendants receive limited formal instruction in the proper operation of upper and lower beds.

The written instructions for bed operation, posted in each Superliner® bedroom, did not accurately describe exact procedures for bed operation.

Train Inspection

On March 23-24, 1993, NIOSH investigators rode round-trip on an Amtrak Superliner® train between Chicago and Kansas City. An inspection of the bedroom equipment was conducted. The types of defects relating to beds in Superliner® bedroom cars are presented in Table 3 (in this report, "defect" refers to damaged, or malfunctioning equipment). The majority of beds in the cars were in adequate operating condition. However, in each car there were several beds which were not operating properly, and a few which could not be operated at all. One of the most common defects involved defective outboard stabilizers, including both scissor mechanisms and vertical latching poles. Another common defect involved the wall-mounted plastic 'stops' which act as part of the positive latch mechanism. In many of the rooms these 'stops' were broken, missing the outer cover, or out of place. In one of the rooms in which the 'stop' was defective the bed latch was pushed beyond the plastic stop such that the bed could not be brought into the down position. Several rooms had defective mechanisms holding the beds in the upright position. In some cases, alternative mechanisms, such as a sliding-bolt mechanism, were installed to hold the bed upright. Many of the beds were inadequately secured when latched in the upright position, leading to excess movement of the bed when it should have been in a secured upright position.

System Safety Analysis

The train inspections and the review of the injury records revealed that being struck by an object, fall from elevation, and overexertion are the top three injury types in superliner bedrooms. These three categories were analyzed with the fault tree analysis technique and are discussed below and presented in Figures
1-4. Figure 1 presents an overview of the types of injuries seen in Superliner® bedrooms, three of which are further analyzed in Figures 2-4.

The primary fault events for being **struck by an object** (Figure 2) are:
(1) unsecured nylon straps; (2) missing nylon straps; (3) bent ceiling hooks;
(4) strap latch defect; (5) defective outboard scissor mechanism; (6) loss of balance; (7) broken hinges; (8) failure of release latch; (9) faulty outboard latching system; (10) object on bed falls when bed falls; (11) object on bed not secured; and (12) sudden movement of train. The primary fault events for **overexertion** (Figure 3) injury in the bedrooms are: (1) bed too heavy;
(2) defective bed components; (3) defective latch pole; (4) defective scissor mechanism; (5) inadequate training on how to operate the beds; (6) training guidelines not followed; (7) over-reaching to make beds; (8) transfer of bulky mattress; (9) inadequate working space; and (10) upper bed too high for attendant. The primary fault events for **fall from elevation** (Figure 4) are:
(1) sudden movement of train; (2) failure of ladder; (3) carrying an object while climbing ladder; (4) health condition of train attendant; (5) slippery ladder;

(6) over-reaching while standing on a ladder; (7) stepping on foreign objects;
(8) failure of bed component(s) when attendant is on the bed; and (9) attendant bumps ceiling when on the bed.

Functional Reach Simulation

The results of the computer simulation indicate that most attendants have overexertion exposure potential in setting the upper beds. More than 95% of females and 50% of males will be over-stressed in making the beds when they stand on the floor (two functional reach diagrams are shown in Figures 5 and 6). Approximately 90% of females and 50% of males will not be able to hook or unhook the nylon straps from the ceiling without risk of overexertion.

VI. CONCLUSIONS

Injuries among train attendants working in Superliner® bedrooms make up 12% of injuries among attendants working in all Amtrak bedroom cars. The primary fault events of these preventable injuries are numerous and outlined in the system safety analysis. Inadequate maintenance and inadequate training were identified as factors involved in many of the injuries. The computer simulations indicate that most attendants will have potential for overexertion in setting the upper beds because of the bed dimensions, bed weight, and bed-setting procedures.

VII. RECOMMENDATIONS

1. Maintenance of sleeper cars should be improved so that employees are not required to use malfunctioning equipment while the train is in-service. Train attendants should not be asked to perform maintenance duties outside of their normal duties on equipment which is in disrepair, as this is a potential source of injury.

2. Employee training should be expanded to include formal training in the proper use of the sleeping car equipment, particularly the upper and lower beds. The Employee Instruction Manual should include written instructions on proper methods for bed operation.

3. Installation of the positive latch mechanisms in the deluxe bedroom upper beds should continue until they have been installed in the whole fleet of Superliner® sleeper cars. These positive latch mechanisms provide significant improvement in maintaining the beds in the upright position.

4. Overexertion control approaches should be developed and implemented. A foot stand is suggested for attendants to reduce/prevent the overexertion injuries during bed-making. Attendants should also be advised not to use the adjacent sink as a stand during bed-making because of the potential for tripping and falling.

5. Continued improvement and installation of the bungee cord mechanism is recommended to prevent sudden loads to attendants during bed operation.

6. Supervisory personnel should insure that all injuries be reported and recorded in a timely manner so that injury prevention can be performed most effectively.

7. Written instructions for operation of both the upper and lower beds, which are posted within each room, should be rewritten to reflect the exact operating procedure.

VIII. AUTHORSHIP AND ACKNOWLEDGEMENTS

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1. Transportation Communications International Union
2. National Railroad Passenger Corporation

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TABLE 1
INJURIES ON SLEEPER CARS AMONG AMTRAK EMPLOYEES
HETA 93-531
1/1/86 - 4/30/93

		% ***
Number of Injuries* in Superliner® Bedrooms	22	12%
Number of Injuries* in Amtrak** Bedrooms	182	
Number of Superliner® Bedroom Cars	68	37%
Number of Amtrak** Bedroom Cars	182	
Capacity of Superliner® Bedrooms (# persons)	2992	51%
Capacity of Amtrak** Bedrooms (# persons)	5886	

* Reported to NIOSH from the Amtrak Safety Department.
** Amtrak Bedroom Cars include both Superliner® and Heritage Equipment
*** Percentage of Superliner® Car data compared to all Amtrak Car (Superliner® and Heritage) data

TABLE 2
INJURIES ON Superliner® SLEEPER CARS
HETA 93-531
1/1/86 - 4/30/93

TOTAL NUMBER OF INJURIES = 22	
Number of Cars In Which Injuries Occurred	12 cars with 1 injury reported, 5 cars with 2 injuries reported
Body Part Involved	Arm: 5 Back: 6 Finger/Hand: 3 Shoulder/Neck: 3 Head/Eye: 4 Knee: 2
Type of Injury	Bruise: 11 Sprain: 10 Cut/Laceration: 1
Reason for Injury	Bed fell: 10 Strained moving bed: 6 Other: 6
Job Title of Employee	Train attendant: 20 Carman: 1 Waiter: 1
Lost Days due to Injury	Overall: Mean: 22 Range: 0 - 105 Back Injuries: Mean: 43 Range: 0 - 105 All Except Back: Mean: 18 Range: 0 - 69
Age	Injured Employees: Mean: 39 Range: 23 - 67 All Employees: Mean:41

TABLE 3
TYPES OF DEFECTS NOTED ON Superliner® SLEEPER CARS
HETA 93-531
March 1993

Type of Defect Noted	Room Type*
Outboard latching pole does not lock into ceiling mount	D
Outboard latching pole ceiling mounts loose	D
Neutral float of bed when in up position	D
Outboard scissor mechanism loose at upper end	F
Defective mechanism to hold bed in up position:	
Key-ring-type hook to hold bed in up position	D
Ceiling hook bent	D
Sliding-bolt mechanism used to hold bed in up position	E
Covers missing from wall attachments	E
Wall attachments broken	E
Nylon straps tied in knots to prevent slippage	D
One of two nylon straps missing	D
Increased amount of force required to put bed into up position or take bed down from up position**	D,E

* D - Deluxe bedroom; E - Economy; F - Family room.

** Measurements of force estimated

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer and authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

FIGURE 1 - Fault Tree Analysis for Injuries in Superliner® Bedrooms

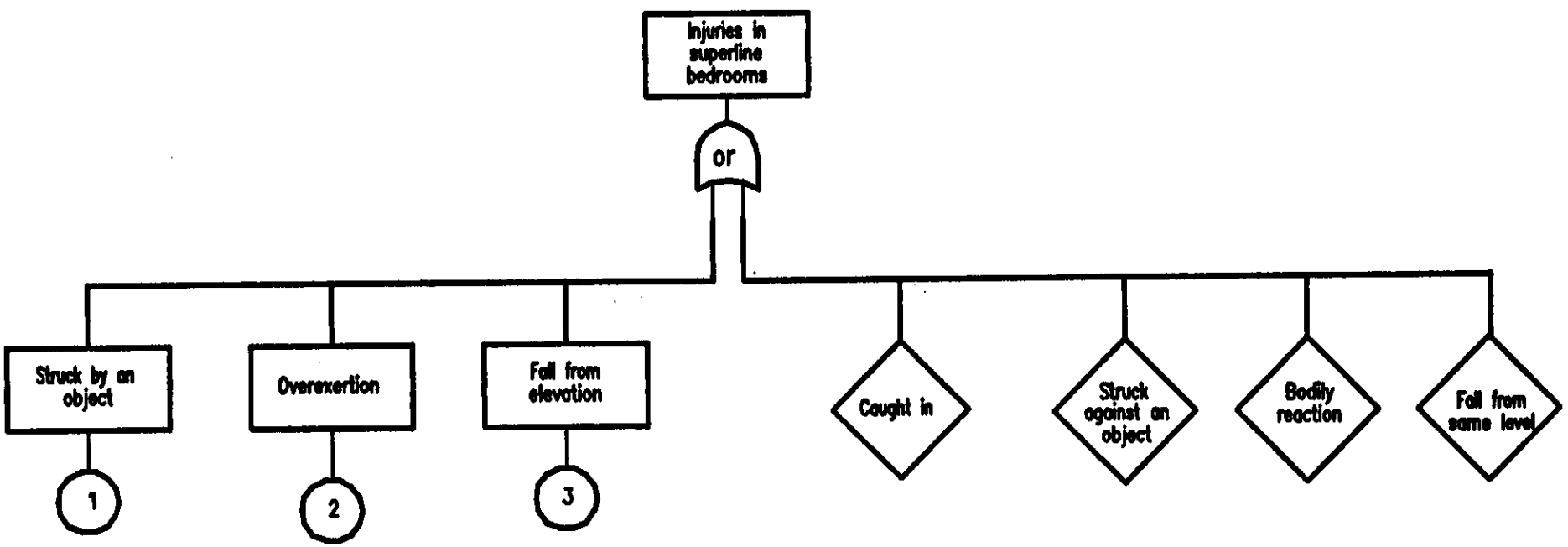


FIGURE 2 - Fault Tree Analysis for Being Struck by Object

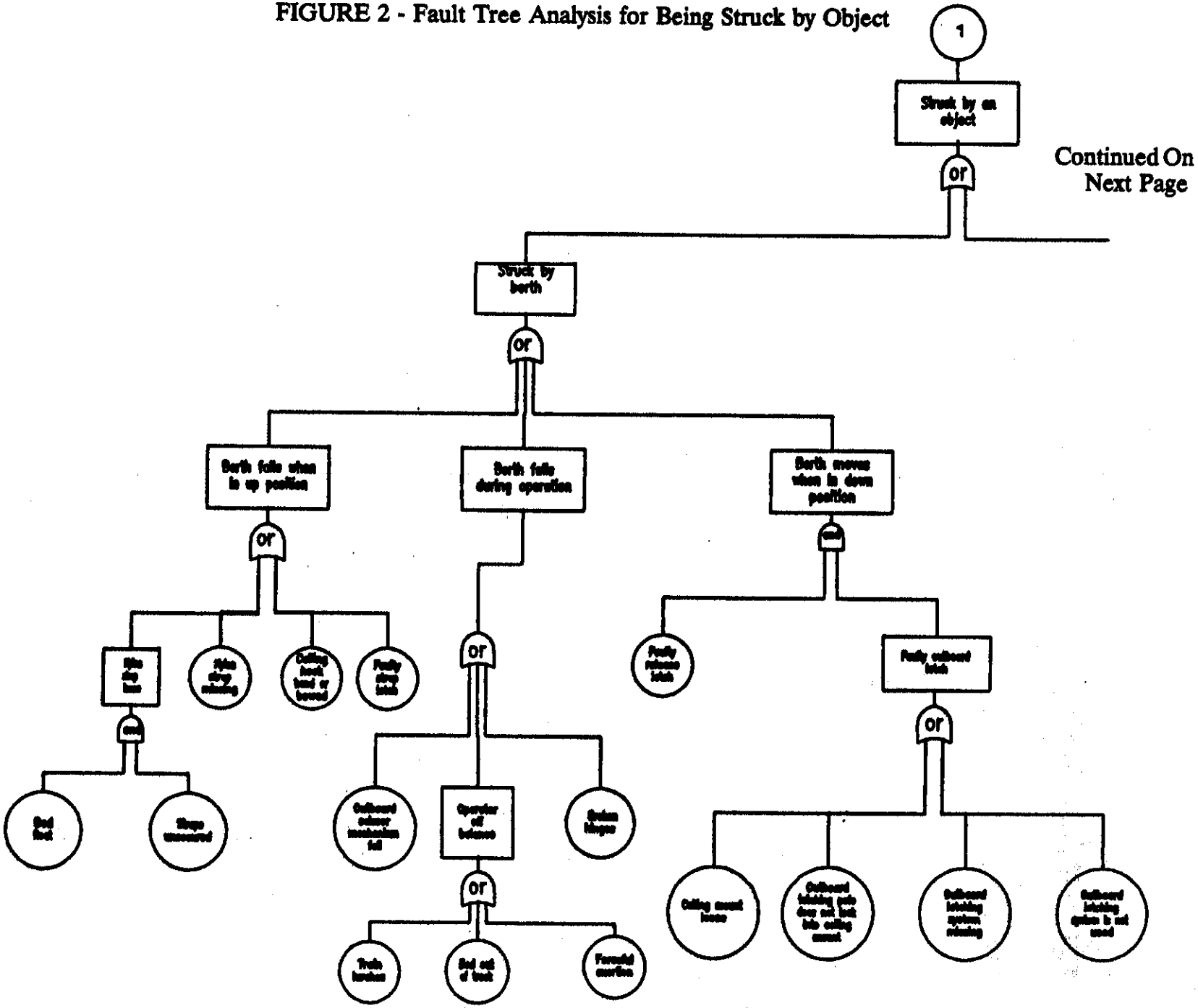


FIGURE 2 CONTINUED

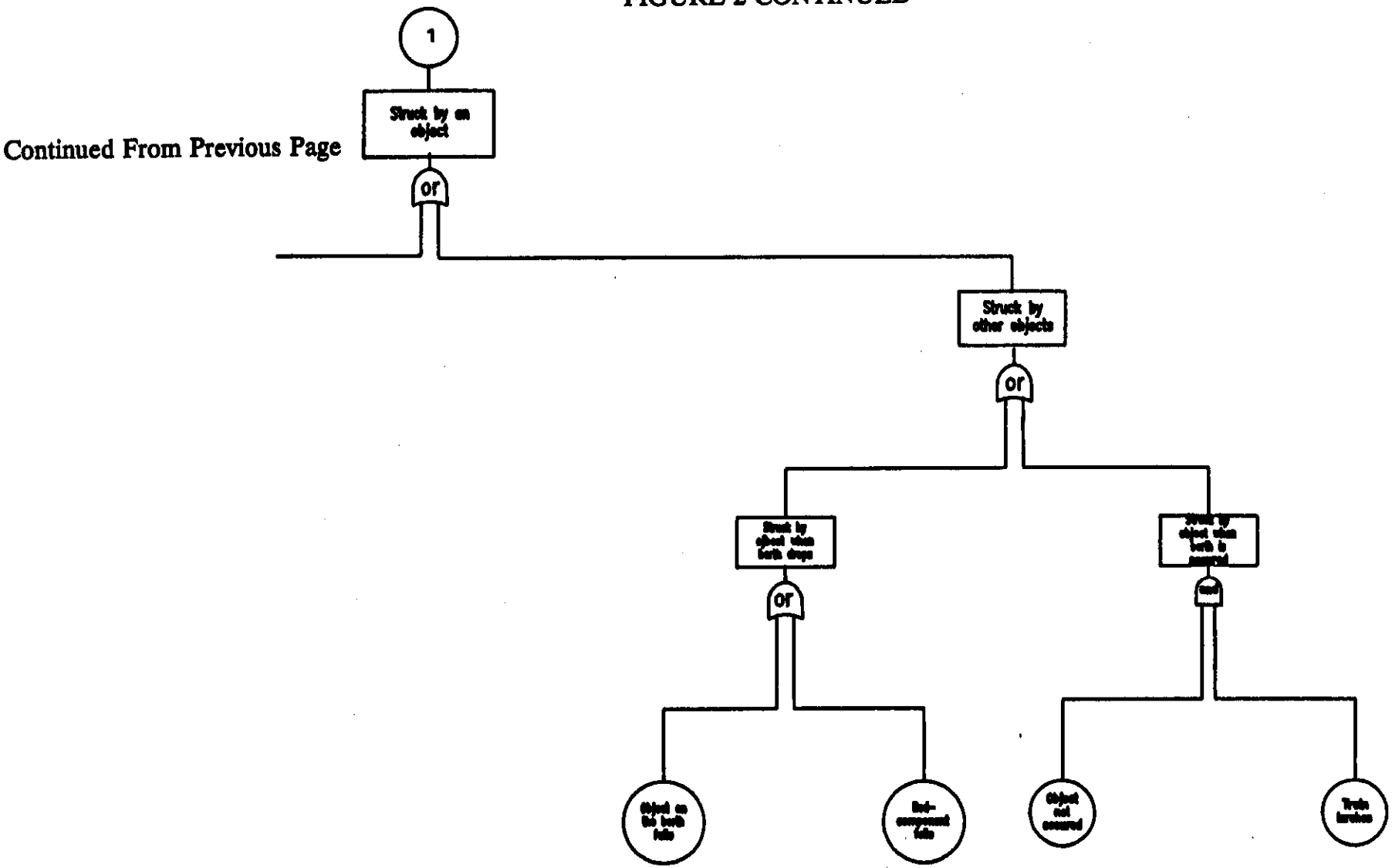
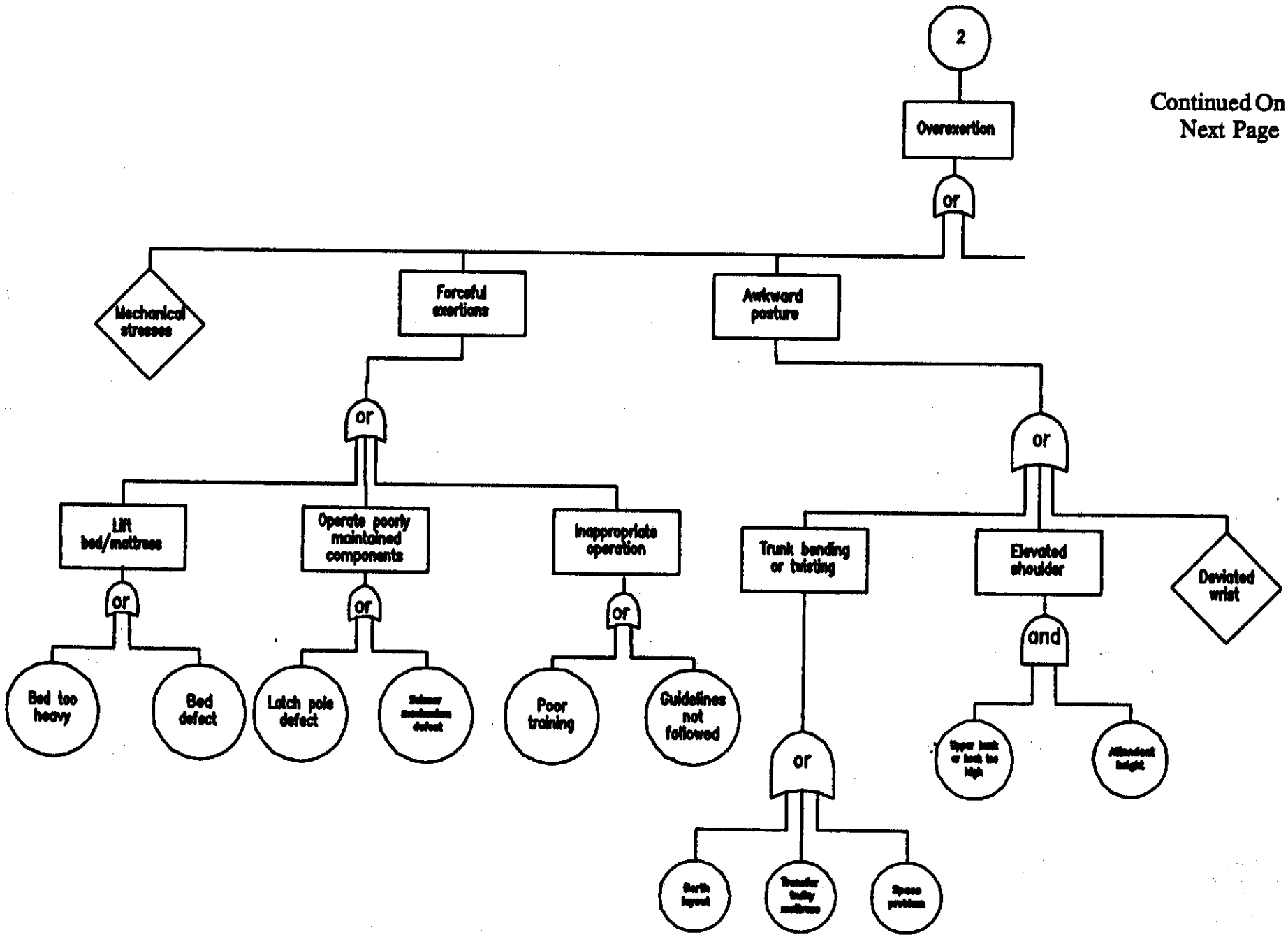


FIGURE 3 - Fault Tree Analysis for Overexertion



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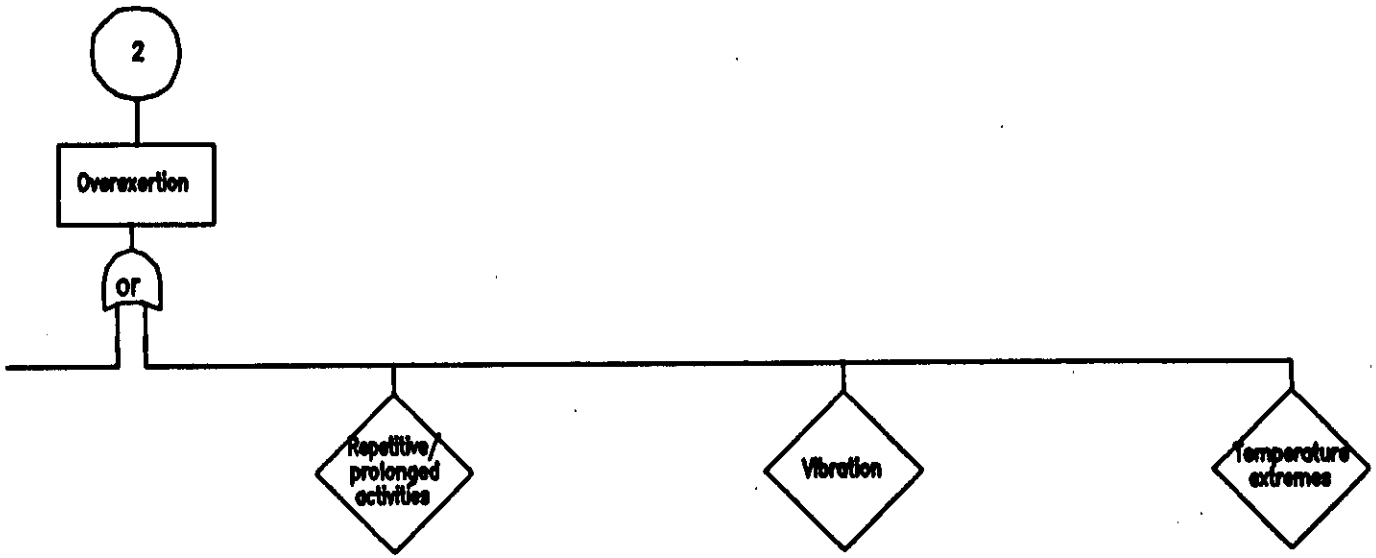

FIGURE 4 - Fault Tree Analysis for Fall from Elevation

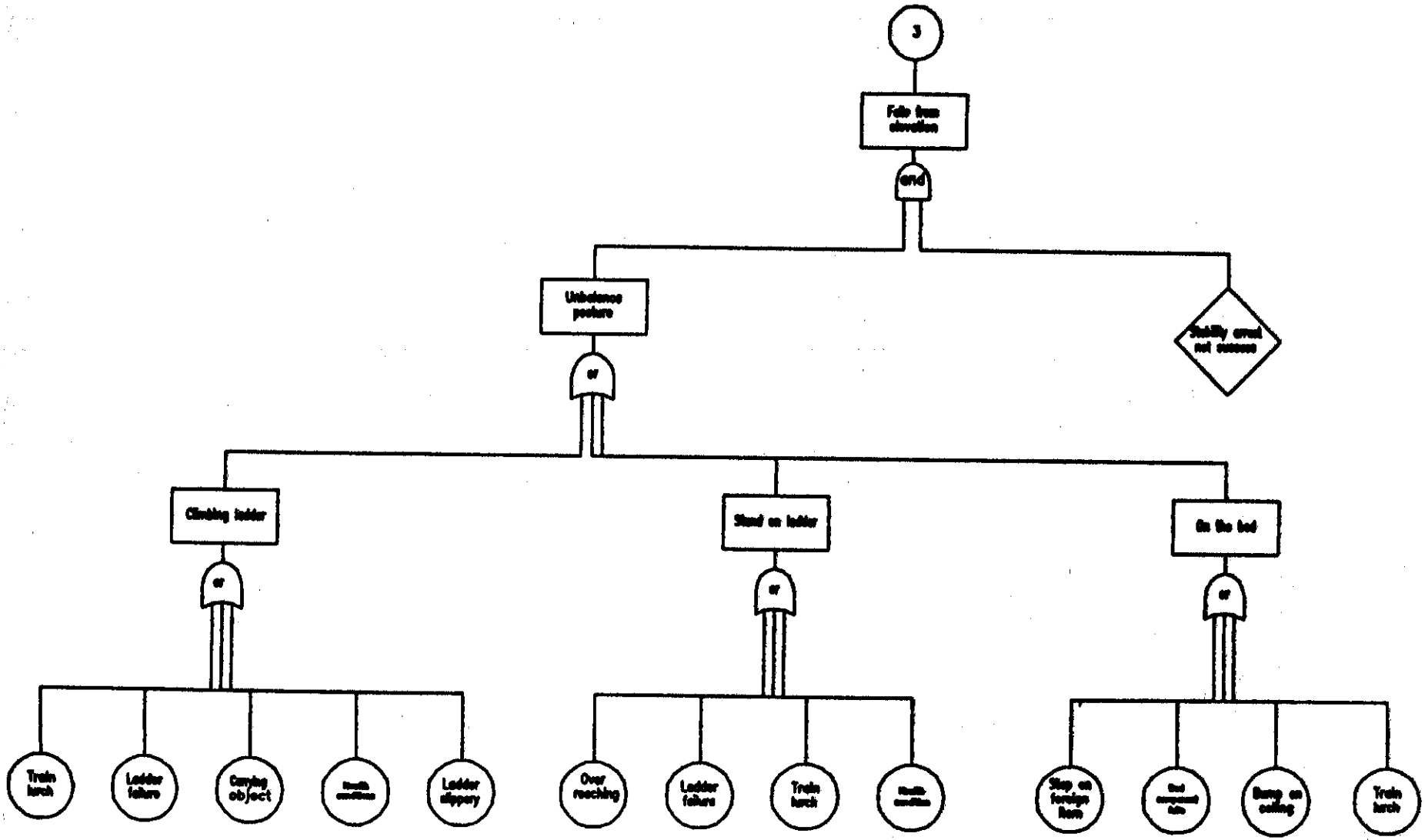

FIGURE 5 - Functional Reach Simulation For Bed-Making
95th Percentile Female

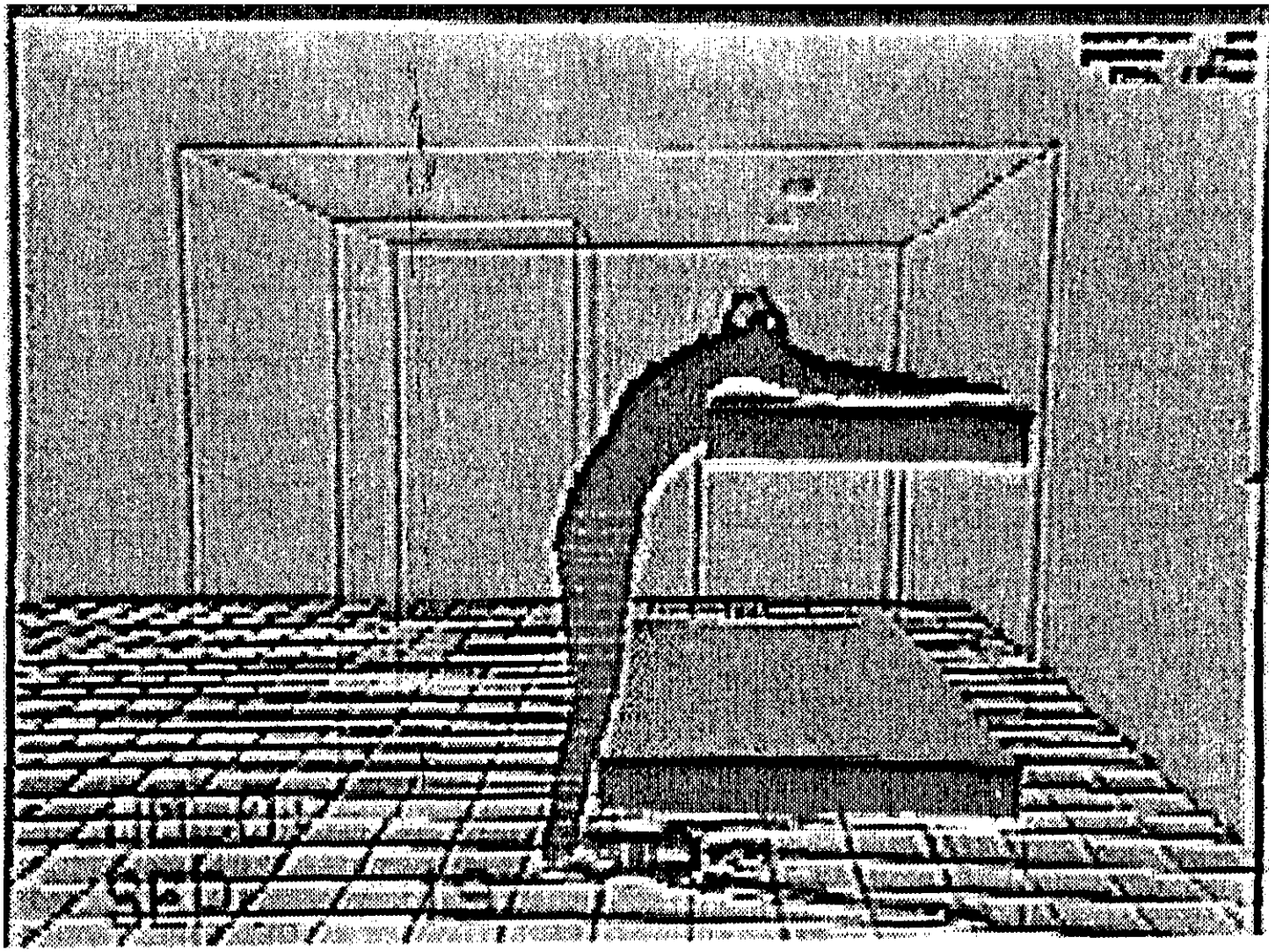

FIGURE 6 - Functional Reach Simulation For Bed-Making
50th Percentile Male